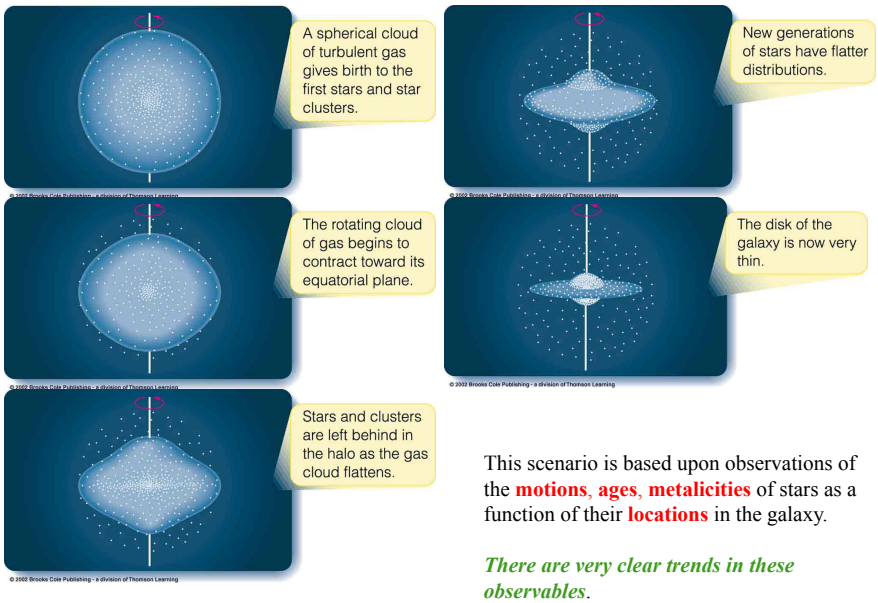
# *CLUES TO THE FORMATION AND EVOLUTION OF THE MILKY WAY*

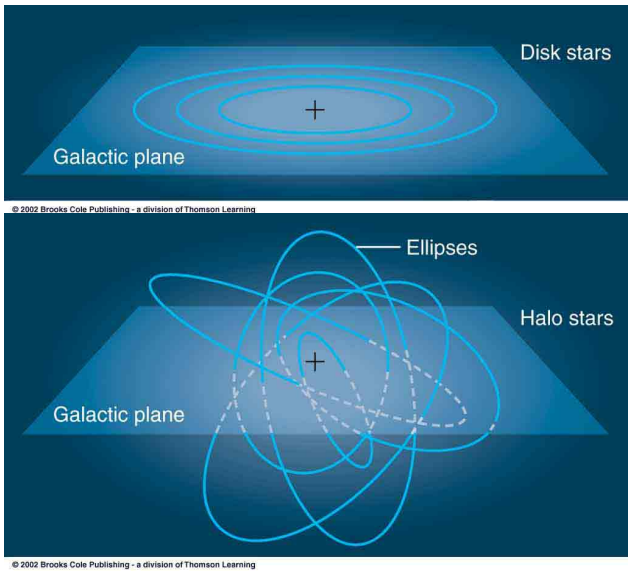
Origin of the Halo and Disk




This scenario is based upon observations of the **motions**, **ages**, **metalicities** of stars as a function of their **locations** in the galaxy.

***There are very clear trends in these observables***.

The motions of disk stars are in a plane.
The motion of Halo stars and clusters are elliptical about the center.




Constructing a Model of the Galaxy and its Formation.

*Two Populations of Stars*: Pop I and Pop II.

**Pop I** stars are younger, formed as a later generation, and have higher metal content.
**Pop II** stars are older, formed in first generation, and have lower metal content.

**Pop I** stars are located in the galaxy disk where stars are continually forming.
**Pop II** stars are located in the bulge, halo, and globular clusters.

| | **Pop I** | | **Pop II** | |
|---|---|---|---|---|
| Property | *Extreme* | *Intermediate* | *Intermediate* | *Extreme* |
| Location | Spiral Arms | Disk | Bulge | Halo |
| Metals (%) | 3 | 1.6 | 0.8 | <0.8 |
| Orbit shape | circular | slight elliptical | moderate elliptical | highly elliptical |
| Average Age (yrs) | 100 million and younger | 0.2-10 billion | 2-10 billion | 10-14 billion |

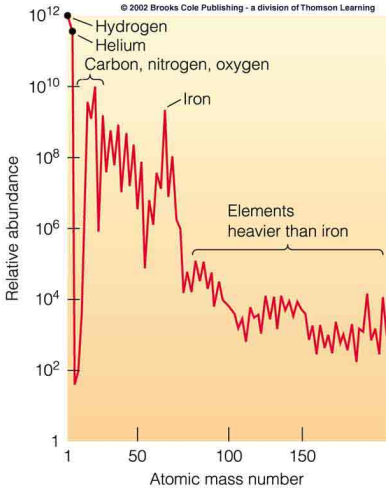
## Heavy Element build up in the Galaxy

Pop II stars are formed first when the Galaxy is contracting from the intergalactic medium.

They reside in the halo and bulge (elliptical orbits) and since they formed first, they are made of primarily hydrogen and helium (light elements).

As the galaxy flattened, 2nd and 3rd generation stars were formed (Pop I stars). These formed from gas that was enriched by Pop II stars! So, Pop I stars have heavier elements in them.

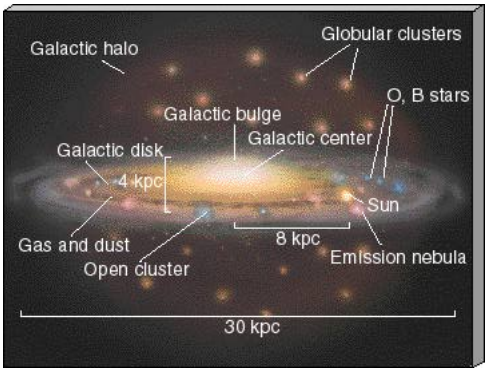
Stars are very efficient at making carbon, nitrogen, oxygen, and iron (in the massive stars).




## And now you know the story...

1. Old, low mass, low metallicity, elliptical orbit stars in the bulge and halo
2. Younger, wide mass range, wide metallicity range, planar orbits in the disk.

*This should now be an intuitive picture in your mind.*

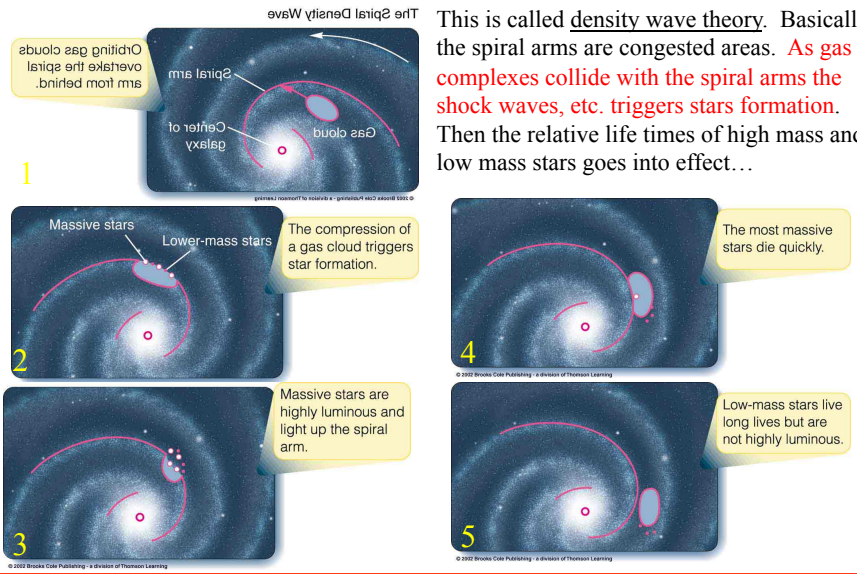



Note the colors; the globular clusters and bulge are reddish (cool low mass stars that are old) whereas the disk stars are ***both*** blue (hot high mass that are young) and reddish.

## Spiral Arms


How do they form?
How are they sustained over many rotations?

## A "model" of Star Formation in Spiral Arms




This is called density wave theory. Basically, the spiral arms are congested areas. As gas complexes collide with the spiral arms the shock waves, etc. triggers stars formation. Then the relative life times of high mass and low mass stars goes into effect…

**The reason this theory is needed is because the spiral arms would dissipate in about 1 billion years.**

## Complex Structure of Spiral Arms



Much structure is seen in spiral galaxies that is not easily explained by the density wave theory.